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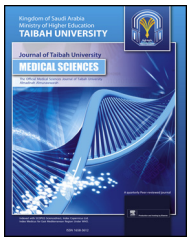

Original Article

Can the association between hypertension and physical activity be moderated by age?

Yong Kang Cheah, Ph.D. [a,*], Kuang Kuay Lim, MSc [b], Hasimah Ismail, MSc [c], Muhammad Fadhli Mohd Yusoff, MMed [c] and Chee Cheong Kee, MSc [d]

[a] *School of Economics, Finance and Banking, College of Business, Universiti Utara Malaysia, Sintok, Kedah, Malaysia*
[b] *Centre for Occupational Health Research, Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia, Shah Alam, Selangor, Malaysia*
[c] *Centre for Non-Communicable Diseases Research, Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia Shah Alam, Selangor, Malaysia*
[d] *Sector for Biostatistics and Data Repository, National Institutes of Health, Ministry of Health Malaysia Shah Alam, Selangor, Malaysia*

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الملخص

أهداف البحث: يعد الخمول البدني وارتفاع ضغط الدم والأمراض غير المعدية من الاهتمامات العامة الرئيسية في جميع أنحاء العالم. على حد علمنا، هناك نقص في الدراسات التي تبحث في التأثير المعدّل للعمر على العلاقة بين ارتفاع ضغط الدم والنشاط البدني في البلدان النامية. هذه الدراسة لها هدفان: (1) استكشاف ارتفاع ضغط الدم والعوامل الاجتماعية والديموغرافية المرتبطة بالنشاط البدني. (2) فحص ما إذا كان العمر يعدل العلاقة بين ارتفاع ضغط الدم والنشاط البدني.

طريقة البحث: تم استخدام بيانات ممثلة على الصعيد الوطني من ماليزيا لتوليد أدلة مستعرضة. بلغ حجم العينة 2156 مستجيبا. تم استخدام الانحدار المرجعي المنظم لتقييم العوامل المرتبطة بممارسة النشاط البدني.

النتائج: كان المستجيبون الذين تتراوح أعمارهم بين 40-49 ولديهم ارتفاع ضغط الدم أقل احتمالا بنسبة 7.3٪ للمشاركة في النشاط البدني عالي المستوى بالمقارنة مع أولئك الذين لا يعانون من ارتفاع ضغط الدم. كان احتمال وجود مستوى منخفض من النشاط البدني أعلى بنسبة 12.3 ٪ بين مرضى ارتفاع ضغط الدم الذين تتراوح أعمارهم بين -60. كان لدى الذكور، والأفراد المتزوجين، والبالغين الأقل تعليما، وذوي الدخل المنخفض، والأفراد الذين كانوا على دراية بمؤشر كتلة الجسم لديهم ميل أكبر للانغماس في نمط حياة نشط للغاية أكثر من غيرهم.

الاستنتاجات: كان تأثير ارتفاع ضغط الدم على النشاط البدني معدلا بالعمر. العوامل التي تؤثر على مستويات النشاط البدني بين البالغين هي الدخل، والجنس، والحالة الاجتماعية، والتعليم، وحالة التوظيف، والوعي بمؤشر كتلة الجسم.

الكلمات المفتاحية: العمر؛ ارتفاع ضغط الدم؛ المتغيرات المعدلة؛ النشاط البدني؛ العوامل الاجتماعية الديموغرافية

Abstract

Objectives: Physical inactivity, hypertension and non-communicable diseases are major public concerns across the globe. To our knowledge, there is a lack of research that has investigated the moderating effect of age on the relationship between hypertension and physical activity in developing countries. This study had two objectives: (1) investigating hypertension and sociodemographic factors associated with physical activity and (2) investigating whether age moderates the relationship between hypertension and physical activity.

Methods: Nationally representative data of Malaysia were used to generate cross-sectional evidence. The

* Corresponding address. School of Economics, Finance and Banking, College of Business, Universiti Utara Malaysia, 06010, Sintok, Kedah, Malaysia
E-mail: yong@uum.edu.my (Y.K. Cheah)

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sample size was 2156 respondents. An ordered probit regression was utilized to assess factors associated with the practice of physical activity.

Results: Respondents aged 40–49 years with hypertension were 7.3% less likely to participate in high-level physical activity when compared to those without hypertension. The probability of having a low level of physical activity was 12.3% higher among hypertensive patients aged ≥60. Males, married individuals, less-educated adults, low-income earners, and individuals who were aware of their BMI, had a higher tendency to indulge in a highly active lifestyle than others.

Conclusion: The effect of hypertension on physical activity was moderated by age. Factors influencing physical activity levels among adults were income, gender, marital status, education, employment status, and BMI awareness.

Keywords: Age; Hypertension; Moderator variables; Physical activity; Sociodemographic factors

Introduction

Hypertension is a serious medical condition, and yet it is preventable.[1,2] Previous studies have emphasised that participation in vigorous and moderate physical activity, a low-sodium diet, and the consumption of plant-based foods and whole grains can effectively reduce blood pressure,[1,2] thereby, preventing hypertension. It is clearly evident that hypertension has severe adverse effects on health as it is highly correlated with various chronic diseases, such as stroke, coronary artery disease, congestive heart failure, and brain damage.[3–5] Almost half of adults across the globe suffer from hypertension.[6] The majority of hypertensive patients are the elderly.[6] There is evidence suggesting that older age is a risk factor for hypertension.[7] In Malaysia, an increasing trend in the prevalence of hypertension has been observed[8,9]; from 2011 to 2019, the prevalence has increased from 12.8% to 15.9%. Most of the hypertensive patients were adults aged 75 years or above (65%).

The use of antihypertensive drugs could be seen as an effective method to control hypertension, but this practice is also accompanied by various side effects, such as renal damage and electrolyte disturbance.[10] Since hypertension is chronic, drug use may not be a desirable long-term solution. Therefore, physical activity has been recommended as an additive solution to control high blood pressure. Being physically active is as effective as drugs in lowering the risk of cardiovascular disease and premature mortality among hypertensive patients.[11–14] Although the advantages of physical activity in chronic disease prevention are well-documented, hypertensive patients may have a low tendency to adopt a physically active lifestyle. The lack of a good health condition could be a plausible barrier to participation in physical activity.[15] Previous studies often focused on how physical activity affects hypertension.[16] Empirical findings about whether hypertensive adults are more or less likely to live a physically active lifestyle are almost non-existent.

In the empirical literature, widespread attention has been given to studies which examine the associations between variables other than hypertension, such as sociodemographic factors (e.g., age, income, and education), and physical activity.[17–32] Previous studies consistently found that age was negatively associated with participation in physical activity.[17,18,25,28] This finding was rationalized by a deterioration in the health status, which may cause older adults to encounter greater barriers to physical activity participation than younger adults.[17] The role of gender in physical activity participation appears to be important. Findings from past studies showed that the likelihood of being physically active was higher among males than females.[19,23,27] This was because in many cultures, males are associated with highly active behaviours.[27] As pointed out by Maruyama and Yin,[32] Downward and Rasciute,[19] Gaskin and Orellana[29] and Choi and Kwon,[31] higher income adults were more likely to participate in physical activity when compared to low income adults. These findings indicated that income increased the value of future healthy days, whereby if physical activity could improve health, people would spend more time on physical activity as income increased.[32] Numerous studies have concluded that education to be negatively associated with physical activity.[25,27,29] AlTamimi et al.[25] reported that well-educated people tended to work in less physically demanding jobs and consequently were less active than their less-educated counterparts. Cheah and Poh[17] and Cheah et al.[18] found that being employed was positively correlated with time spent on physical activity because employed individuals lived a more physically active lifestyle and had better health awareness than the unemployed. Cheah et al.[18] and Choi and Kwon[31] emphasized that family commitments could promote participation in physical activity. Hence, married adults were more likely to engage in physical activity when compared to unmarried adults.

The present study had two objectives: (1) investigating hypertension and sociodemographic factors associated with physical activity and (2) investigating whether age moderates the relationship between hypertension and physical activity. The contributions of the present study to the existing literature are threefold. First, as far as we are aware, the present study is one of very few studies that explores the moderating effect of age on the relationship between hypertension and physical activity. We expect that hypertension has a larger impact on physical activity for older adults compared to younger adults because older hypertensive patients encounter a higher risk of cardiovascular morbidity.[33] Second, in manner that differs from previous studies which treated physical activity as a binary variable (active vs. inactive), the present study made an effort to categorize physical activity into three levels (low, moderate, and high) and uses an ordinal regression, ordered probit, to investigate factors associated with the probabilities of

having these levels of physical activity. Third, apart from sociodemographic factors and hypertension, we added awareness of the body mass index (BMI) variable to our analysis. While previous studies investigated the effects of obesity and overweight on physical activity, none had considered awareness of the BMI variable.[23,25,29]

Materials and Methods

Data

This is a cross-sectional study using secondary data that were extracted from the *Komuniti Sihat Pembina Negara* (KOSPEN) 2016.[34] The Ministry of Health Malaysia conducted the survey across all states in Malaysia. The survey period was from May to June 2016. The survey's objective was to gather important information on health status and lifestyle behaviours among Malaysian adults. With this information, a more effective non-communicable disease (NCD) control and prevention policy could be implemented. The survey used a two-stage stratified cluster sampling protocol in an effort to collect a nationally representative sample. All states across Malaysia were included in the primary stratum. In the secondary stratum, localities were selected according to the community development department (KEMAS) and neighbourhood watch (KRT).

Localities and living quarters (LQs) were selected in the first and second stages, respectively. The total numbers of localities and LQs in Malaysia were 103 and 2660, correspondingly. Out of all the KEMAS and KRT localities, 20−40 LQs were selected, which represented the entire population of Malaysia. In the selected LQs, Malaysian adults aged 18 years or above were selected according to the Kish grid.[35] Institutionalized individuals, such as those staying in hospitals and hotels, were excluded from the survey. The survey used the formula for a prevalence study to calculate sample size. Of the targeted sample size of 2354 respondents, only 2156 were interviewed (a response rate of 91.6%); this was because some respondents did not provide consent.

Trained interviewers used piloted, structured questionnaires to interview respondents. The main language of the questionnaire was the Malay language. This was translated to English by a professional translator. Nevertheless, a backward translation was performed. While there was no procedure that tested the interviewers' ability to obtain similar information from the same respondents, all the field supervisors, interviewers, and team leaders were provided with comprehensive training to minimize non-sampling errors. Questionnaire briefing and mock interviews were conducted during the training period. In addition, field supervisors made an effort to screen all the completed questionnaires at the end of the survey. Respondents were requested to provide written consent before the interviews. The survey was approved by the Medical Research and Ethics Committee of Ministry of Health Malaysia (NMRR-16-524-30085) and is described in more detail elsewhere.[34]

Response variable

The response variable used in the present study, level of physical activity, is a categorical variable with an ordinal outcome: low-, moderate- and high-level physical activity. Levels of physical activity were measured based on metabolic equivalent of task (MET).[36] MET is the ratio of exercising metabolic rate to resting metabolic rate. Moderate-intensity physical activity is referred to as 4.0 MET while vigorous-intensity physical activity is referred to as 8.0 MET. According to Macek et al.,[37] low-, moderate- and high-level physical activity refers to $<$600, 600−1500 and $>$1500 MET-time per week of physical activity, respectively. In the present study, all types of physical activity (leisure, work, and travel) were grouped together for analysis. Because the questionnaires did not have specific and separate questions related to leisure-, work- and travel-time physical activity, analyses stratified by the types of physical activity could not be conducted.

Information on the physical activity levels of respondents was derived from the following questions: (1) 'In the past 7 days, on how many days did you do any vigorous physical activities for at least 10 min at a time?'; (2) 'On the days that you did vigorous physical activities, how much time did you spend doing it?'; (3) 'In the past 7 days, on how many days did you do any moderate physical activities for at least 10 min at a time?' and (4) 'On the days that you did moderate physical activities, how much time did you spend doing it?' The answers for these four questions were used to calculate the total MET-time per week. During the interview, the definitions of vigorous and moderate physical activities were explained by the interviewers. For instance, respondents were told that the talk test (i.e., talking while exercising) could be used as one of the methods for measuring the intensity of physical activity. To facilitate a better understanding of physical activity, the interviewers provided respondents with examples of vigorous (e.g., vigorous cycling, lifting heavy weights, and aerobics) and moderate physical activity (e.g., mopping the floor, lifting light weights, and cycling at normal speed).

Explanatory variables

The explanatory variables (age, income, gender, ethnicity, educational levels, marital status, employment status, awareness of BMI, being diagnosed with hypertension) were selected based on previous findings concerning factors associated with participation in physical activity.[17−32] The age of respondents was segmented into five groups: 18−29, 30−39, 40−49, 50−59 and $\geq$60 years. The monthly incomes of respondents (in Ringgit Malaysia [RM]) were formatted as a qualitative variable with seven categories: $<$RM 1000, RM 1000−1999, RM 2000−2999, RM 3000−3999, RM 4000−4999, RM 5000−5999 and $\geq$RM 6000.

Respondents were asked to report their gender (male, female) and ethnic backgrounds (Malay, Chinese, Indian, other ethnic groups [Others]). The questionnaires also asked respondents to report whether they had formal, primary-, secondary- or tertiary-level education. To facilitate a comparison between well- and less-educated respondents, no formal, primary-level and secondary-level education were combined to form a single category, which was named as 'non-tertiary'.

Marital status was grouped into three categories: single, married and divorced/widowed. The employment status of

respondents was categorized into two groups: employed and unemployed (e.g., retirees, students, and housewives). With regards to the awareness of BMI, respondents were asked: 'Are you aware of your BMI?' The possible answers were 'yes' and 'no'. The definition of BMI was provided by the interviewers. Respondents were asked to report whether they weighed themselves on a regular basis, and whether they knew their BMI. However, due to resources constraints, the survey did not recruit health professionals, such as medical doctors and nurses, to help measure anthropometry. Therefore, information relating to the respondents' current BMI and waist circumference was unavailable for analysis. Nevertheless, the blood pressure of each respondent was assessed by interviewers using digital automatic blood pressure monitors. Hypertensive respondents were those with systolic/diastolic blood pressure of more than 140/90 mmHg.

Statistical analyses

Because some respondents did not report complete information, only 1954 observations were used in the analyses. Descriptive statistics were computed prior to performing any statistical tests. Given that age and income are categorical variables with an ordinal outcome, a non-parametric test for trend, developed by Cuzick,[38] was used to examine age and income variations in the levels of physical activity. For other variables, Pearson's chi-squared tests for independence were employed. In terms of multivariate analysis, the present study utilized an ordered probit regression model to assess the independent relationships between levels of physical activity and sociodemographic, hypertension, and BMI awareness variables. The marginal effect of each explanatory variable was calculated and interpreted. One of the unique contributions of the present study was the use of an ordinal response variable and an ordinal regression to examine factors influencing the probabilities of participating in low-, moderate- and high-level physical activity. To test for the moderating effect of age on the relationship between hypertension and physical activity, interactions between age and hypertension were added to the model. In addition, in order to identify whether the interaction terms and BMI awareness variable were relevant, three regression models were developed. Model 1 consisted of only sociodemographic variables, Model 2 included interaction terms, and Model 3 added the BMI awareness variable. These three models were compared based on their Pseudo R-squared and Akaike information criterion (AIC). To ensure that the models did not have any specification error and multicollinearity, a link test developed by Pregibon[39] was conducted and variance inflation factors (VIFs) were computed. A significance level of $p < 0.05$ was selected. All statistical analyses were performed using Stata statistical software.[40]

Results

Table 1 illustrates the descriptive statistics. A large proportion of the respondents participated in high-level physical activity (42.8%), followed by those with low (25%) and moderate levels of physical activity (32.2%). Approximately 22.7% of respondents were aged ≥60 years; only 17.6% were aged 18–29 years. Only a small proportion of respondents had monthly incomes of RM 4000–4999 (5.8%), RM 5000–5999 (5.1%) and RM ≥ 6000 (5.5%). The majority of respondents were Malays (76.5%), without tertiary-level education (80.8%) and were married (70.9%). Slightly more than 50% of respondents were currently employed (60.3%) and unaware of their BMI (54.8%). Almost one quarter of respondents had hypertension (22.7%) (Table 1).

Table 2 shows the results of trend tests and Pearson's chi-squared tests. The prevalence of low- and moderate-level physical activity was the highest among respondents aged ≥60 (37.5%) and 18–29 (38.1%). The prevalence of high-level physical activity was the lowest in the ≥60 age group (33.4%). Comparing between income groups, only a very

Table 1: Summary statistics of variables (n = 1954).

Variables	Frequency	Percent
Response		
Physical activity		
Low-level	488	24.97
Moderate-level	630	32.24
High-level	836	42.78
Explanatory		
Age (years)		
18–29	344	17.60
30–39	359	18.37
40–49	419	21.44
50–59	389	19.91
≥60	443	22.67
Income (RM)		
<1000	516	26.41
1000–1999	565	28.92
2000–2999	343	17.55
3000–3999	210	10.75
4000–4999	114	5.83
5000–5999	99	5.07
≥6000	107	5.48
Gender		
Male	883	45.19
Female	1071	54.81
Ethnicity		
Malay	1494	76.46
Chinese	74	3.79
Indian	72	3.68
Others	314	16.07
Education		
Tertiary	376	19.24
Non-tertiary	1578	80.76
Marital status		
Single	311	15.92
Married	1386	70.93
Divorced/widowed	257	13.15
Employment status		
Employed	1178	60.29
Unemployed	776	39.71
BMI awareness		
Aware	883	45.19
Unaware	1071	54.81
Hypertension		
Yes	444	22.72
No	1510	77.28

Source: KOSPEN 2016.

Table 2: Number and proportion of respondents with low-, moderate- and high-level physical activity (n = 1954).

Variables	Low-level	Moderate-level	High-level
Age (years)			
18–29	79 (22.97)	131 (38.08)	134 (38.95)
30–39	79 (22.01)	127 (35.38)	153 (42.62)
40–49	85 (20.29)	136 (32.46)	198 (47.26)
50–59	79 (20.31)	107 (27.51)	203 (52.19)
≥60	166 (37.47)	129 (29.12)	148 (33.41)
p-value	0.015#		
Income (RM)			
<1000	138 (26.74)	146 (28.29)	232 (44.96)
1000–1999	135 (23.89)	157 (27.79)	273 (48.32)
2000–2999	74 (21.57)	134 (39.07)	135 (39.36)
3000–3999	48 (22.86)	74 (35.24)	88 (41.90)
4000–4999	37 (32.46)	47 (41.23)	30 (26.32)
5000–5999	24 (24.24)	34 (34.34)	41 (41.41)
≥6000	32 (29.91)	38 (35.51)	37 (34.58)
p-value	0.007#		
Gender			
Male	221 (25.03)	226 (25.59)	436 (49.38)
Female	267 (24.93)	404 (37.72)	400 (37.35)
p-value	<0.001#		
Ethnicity			
Malay	372 (24.90)	470 (31.46)	652 (43.64)
Chinese	26 (35.14)	23 (31.08)	25 (33.78)
Indian	20 (27.78)	26 (36.11)	26 (36.11)
Others	70 (22.29)	111 (35.35)	133 (42.36)
p-value	0.224		
Education			
Tertiary	98 (26.06)	141 (37.50)	137 (36.44)
Non-tertiary	390 (24.71)	489 (30.99)	699 (44.30)
p-value	0.014#		
Marital status			
Single	79 (25.40)	107 (34.41)	125 (40.19)
Married	324 (23.38)	438 (31.60)	624 (45.02)
Divorced/widowed	85 (33.07)	85 (33.07)	87 (33.85)
p-value	0.003#		
Employment status			
Employed	256 (21.73)	355 (30.14)	567 (48.13)
Unemployed	232 (29.90)	275 (35.44)	269 (34.66)
p-value	<0.001#		
BMI awareness			
Aware	197 (22.31)	286 (32.39)	400 (45.30)
Unaware	291 (27.71)	344 (32.12)	436 (40.71)
p-value	0.031#		
Hypertension			
Yes	153 (34.46)	132 (29.73)	159 (35.81)
No	335 (22.19)	498 (32.98)	677 (44.83)
p-value	<0.001#		

Note: For age and income variables, *p*-values for trend test are presented. For other variables, *p*-values for Pearson's chi-squared test are presented. Row percentages are shown in parentheses. The significance level was $p < 0.05$. #$p < 0.05$.
Source: KOSPEN 2016.

small proportion of respondents with incomes of RM 2000–2999 (21.6%), RM 1000–1999 (27.8%) and RM 4000–4999 (26.3%) participated in low-, moderate- and high-level physical activity, respectively. Participation in low- and high-level physical activity was more prevalent among males (25–49.4%) than females (24.9–37.4%). Compared with others, the prevalence of low- and moderate-level physical activity was higher among respondents with tertiary-level education (26.1–37.5%) and the unemployed (29.9–35.4%), while high-level physical activity was more frequent among respondents who were aware of their BMI (45.3%) and without hypertension (44.8%). These significant trends and variations provided support for the use of an ordinal regression to examine the independent effects of hypertension and sociodemographic variables on physical activity (Table 2).

Table 3 compares three different regression models. Comparing between all three models, Model 3 was the most appropriate model because it had the highest Pseudo R-squared value and the lowest AIC. This implied that

Table 3: Correlates of sociodemographic and hypertension variables to physical activity (n = 1954).

Variables	Model 1	Model 2	Model 3
Age (years)			
18–29	Ref.	Ref.	Ref.
30–39	0.024 (0.090)	0.017 (0.092)	0.010 (0.092)
40–49	0.099 (0.093)	0.074 (0.096)	0.082 (0.096)
50–59	0.237# (0.100)	0.288# (0.108)	0.291# (0.108)
≥60	−0.222# (0.110)	−0.289# (0.119)	−0.268# (0.119)
Income (RM)			
<1000	Ref.	Ref.	Ref.
1000–1999	−0.024 (0.074)	−0.024 (0.074)	−0.025 (0.075)
2000–2999	−0.140# (0.082)	−0.140# (0.082)	−0.150# (0.082)
3000–3999	−0.144 (0.099)	−0.139 (0.099)	−0.160 (0.099)
4000–4999	−0.515# (0.118)	−0.515# (0.118)	−0.535# (0.118)
5000–5999	−0.185 (0.133)	−0.178 (0.134)	−0.192 (0.134)
≥6000	−0.396# (0.135)	−0.395# (0.135)	−0.431# (0.136)
Gender			
Male	0.086 (0.061)	0.088 (0.061)	0.101 (0.062)
Female	Ref.	Ref.	Ref.
Ethnicity			
Malay	Ref.	Ref.	Ref.
Chinese	−0.274# (0.140)	−0.278# (0.140)	−0.280# (0.139)
Indian	−0.136 (0.135)	−0.149 (0.135)	−0.148 (0.136)
Others	−0.037 (0.070)	−0.032 (0.071)	−0.032 (0.071)
Education			
Tertiary	−0.118 (0.077)	−0.118 (0.077)	−0.139 (0.078)
Non-tertiary	Ref.	Ref.	Ref.
Marital status			
Single	Ref.	Ref.	Ref.
Married	0.111 (0.086)	0.111 (0.086)	0.100 (0.087)
Divorced/widowed	−0.023 (0.119)	−0.024 (0.119)	−0.026 (0.119)
Employment status			
Employed	0.227# (0.064)	0.226# (0.064)	0.222# (0.064)
Unemployed	Ref.	Ref.	Ref.
BMI awareness			
Aware	–	–	0.151# (0.055)
Unaware	–	–	Ref.
Hypertension			
Yes	−0.210# (0.072)	−0.820# (0.373)	−0.861# (0.383)
No	Ref.	Ref.	Ref.
Hypertension*30–39	–	0.578 (0.444)	0.605 (0.451)
Hypertension*40–49	–	0.725# (0.407)	0.766# (0.415)
Hypertension*50–59	–	0.441 (0.396)	0.471 (0.405)
Hypertension*≥60	–	0.725# (0.391)	0.764# (0.399)
Wald	121.420	127.630	135.160
p-value	<0.001#	<0.001#	<0.001#
Prediction squared	0.366	0.259	0.098
p-value	0.124	0.250	0.650
Maximum VIF	3.310	3.310	3.330
Pseudo R-squared	0.030	0.031	0.033
AIC	4115.386	4118.355	4112.626

Note: The entries refer to estimated coefficients from ordered probit regression. Robust standard errors are shown in parentheses. Ref refers to reference groups. VIFs for interaction terms are not calculated. The significance level was $p < 0.05$. #$p < 0.05$.
Source: KOSPEN 2016.

BMI awareness and age–hypertension interactions were relevant variables. Model specification was not an issue because the prediction squared was insignificant. Furthermore, the maximum VIF was <10, thus indicating that the model did not exhibit multicollinearity (Table 3).[41]

Table 4 presents the marginal effects of all explanatory variables. Among respondents aged 40–49, those with hypertension were 7.3% less likely to participate in high-level physical activity when compared to those without hypertension. These hypertensive respondents also had a 14.8% higher probability of having a low physical activity level. The probability of engaging in high-level physical activity was 9.5% lower among hypertensive respondents aged ≥60 than non-hypertensive respondents. These individuals were also 12.3% more likely to have a low level of physical activity (Table 4).

Table 4: Marginal effects from an ordered probit regression (n = 1954).

Variables	Low-level	Moderate-level	High-level
Age (years)			
18–29	Ref.	Ref.	Ref.
30–39	−0.003 (0.028)	−0.001 (0.008)	0.004 (0.036)
40–49	−0.025 (0.029)	−0.007 (0.009)	0.032 (0.038)
50–59	−0.084# (0.029)	−0.031# (0.014)	0.115# (0.043)
≥60	0.087# (0.041)	0.016# (0.005)	−0.103# (0.045)
Income (RM)			
<1000	Ref.	Ref.	Ref.
1000–1999	0.008 (0.023)	0.002 (0.006)	−0.010 (0.029)
2000–2999	0.048# (0.027)	0.010# (0.004)	−0.058# (0.031)
3000–3999	0.052 (0.033)	0.010# (0.005)	−0.062 (0.038)
4000–4999	0.189# (0.045)	0.004 (0.009)	−0.193# (0.038)
5000–5999	0.063 (0.046)	0.011# (0.004)	−0.074 (0.050)
≥6000	0.150# (0.051)	0.009 (0.006)	−0.159# (0.046)
Gender			
Male	−0.031 (0.019)	−0.008 (0.005)	0.039 (0.024)
Female	Ref.	Ref.	Ref.
Ethnicity			
Malay	Ref.	Ref.	Ref.
Chinese	0.094# (0.050)	0.012# (0.002)	−0.106# (0.050)
Indian	0.048 (0.046)	0.009 (0.006)	−0.057 (0.051)
Others	0.010 (0.022)	0.003 (0.005)	−0.013 (0.028)
Education			
Tertiary	0.045# (0.026)	0.010# (0.004)	−0.054# (0.030)
Non-tertiary	Ref.	Ref.	Ref.
Marital status			
Single	Ref.	Ref.	Ref.
Married	−0.031 (0.028)	−0.007 (0.006)	0.039 (0.034)
Divorced/widowed	0.008 (0.037)	0.002 (0.009)	−0.010 (0.046)
Employment status			
Employed	−0.070# (0.020)	−0.016# (0.005)	0.087# (0.025)
Unemployed	Ref.	Ref.	Ref.
BMI awareness			
Aware	−0.047# (0.017)	−0.013# (0.005)	0.059# (0.022)
Unaware	Ref.	Ref.	Ref.
Hypertension			
Yes	0.300# (0.141)	0.006 (0.025)	−0.306# (0.117)
No	Ref.	Ref.	Ref.
Hypertension*30–39	−0.146# (0.078)	−0.090 (0.088)	0.236 (0.166)
Hypertension*40–49	−0.173# (0.060)	−0.121 (0.083)	0.294# (0.143)
Hypertension*50–59	−0.124 (0.087)	−0.062 (0.070)	0.186 (0.157)
Hypertension*≥60	−0.184# (0.069)	−0.112 (0.074)	0.296# (0.143)

Note: Robust standard errors are shown in parentheses. Ref refers to reference groups. The significance level was $p < 0.05$. #$p < 0.05$.
Source: KOSPEN 2016.

Respondents with incomes of RM 2000–2999, RM 4000–4999 and RM ≥ 6000 were 5.8%, 19.3% and 15.9% less likely to participate in high-level physical activity, respectively, compared with those having an income of RM < 1000. Chinese and respondents with tertiary-level education were 1.2–9.4% and 1–4.5% more likely to have low and moderate levels of physical activity, respectively, compared with others. The probability of being highly active was 8.7% higher among employed respondents than the unemployed. Being aware of BMI increased the likelihood of participating in high-level physical activity by 5.9% and reduced the probability of having low and moderate physical activity levels by 4.7% and 1.3%, respectively.

Discussion

The present study used nationally representative data of Malaysia and a rigorous statistical method to examine the influences of hypertension and sociodemographic factors on levels of physical activity, as well as the moderating effects of age. Less than half of Malaysian adults participated in high-level physical activity, and only one-third indulged in moderate-level physical activity. This finding was comparable to evidence reported by Cheah and Poh,[17] who found that nearly 50% of Malaysian adults were physically inactive. The high prevalence of physical inactivity in Malaysia may be a factor contributing to the rise in non-communicable

diseases (NCDs), but this claim must be confirmed in a future empirical study. Hypertension was found to be independently correlated with physical activity; this correlation was moderated by age. Sociodemographic factors that were found to be associated with physical activity included gender, marital status, income, education, and employment status, as well as awareness of BMI.

In the present study, age moderated the relationship between hypertension and levels of physical activity. In particular, adults with hypertension had a lower likelihood of being highly active when compared with those without hypertension across age groups. These differences in likelihood became larger when the age of respondents increased from 40 to 49 to $\geq$60 years, thus indicating that the negative relationship between hypertension and physical activity was more profound among older adults than younger adults. Our finding is consistent with our hypothesis that hypertension has a larger impact on older adults as older adults with hypertension are likely to experience more physical constraints on exercises when compared to their younger counterparts. Furthermore, hypertension was more prevalent among older adults. It is also noteworthy that without taking account of the moderating effect, both age and hypertension were negatively associated with high-level physical activity. This negative association between age and physical activity was also detected in previous studies.[17,18,25,28] A decline in biological functions was the given explanation.[29] For instance, the elderly are more likely to suffer from osteoarthritis. While hypertensive patients were encouraged to be physically active in order to control their blood pressure, they faced obstacles with regards to engaging in physical activity. As pointed out by Gebrezgi et al.,[42] hypertensive patients often thought that physical activity could hurt their body and increase their stress level; consequently, there were less devoted to participation in physical activity. In addition, Cascino et al.[15] claimed that the lack of energy, self-discipline and interest was the main barrier to frequent physical activity participation among hypertensive patients.

A previous study examining physical activity among the elderly in several low- and middle-income countries found that household income was positively associated with the odds of being physically active.[29] Studies exploring physical activity in high-income countries suggested likewise. In particular, higher income adults were more likely to indulge in a physically active lifestyle than lower income adults.[19,31,32] Surprisingly, however, in the present study, high-income was found to be a risk factor for physical inactivity. More specifically, higher income adults were less likely to participate in high-level physical activity and were more likely to have a low level of physical activity compared with their lower income counterparts. A plausible explanation for this conflicting outcome is that higher income adults tend to spend more time at work than lower income adults because they face greater challenges in their job and consequently may allocate less time to physical activity.[25] The fact that individuals who earn a high salary encounter a high opportunity cost of not working could be another reason explaining the reduction in time spent on physical activity among high-income adults.[17] Of note, although leisure-time physical activity was often found to be more frequent among higher income earners than lower income earners in past studies, findings from the present study showed otherwise because the physical activity analysed in the present study consisted of all types of physical activity (leisure, work and travel).

In previous studies, the relationship between education and physical activity was inconclusive. Based on data collected in the US, Iran and Korea, education levels did not have any significant effect on physical activity.[21,26,31] However, findings from other studies showed that educational levels were negatively correlated with physical activity.[25,29] Werneck et al.[27] focussed on several South American countries and also concluded that levels of physical activity were lower among more educated individuals than less-educated individuals. Similar findings were evidenced in the present study, which showed well-educated adults to be less likely to indulge in a highly active lifestyle when compared to their less-educated counterparts. These findings could be explained by several plausible reasons. First, although well-educated adults have a high awareness of physical activity, they tend to work in white collar jobs, which are less physically demanding.[25] Second, more educated people have a higher opportunity cost of time compared with less-educated people because they earn higher wages.[20] Third, since more educated individuals have better health knowledge than less-educated individuals, they may use other effective methods to improve their health, such as the use of dietary supplements and adherence to a healthy eating lifestyle.[18] The findings of the present study were in contrast to the popular belief that education levels had positive effects on physical activity as well as the empirical evidence of Pitanga et al.[43] This was because the present study grouped leisure-, work- and travel-time physical activity into a single category for analysis, whereas Pitanga et al.[43] only considered leisure-time physical activity. Pitanga et al.[43] pointed out that education levels were positively associated with leisure-time physical activity as participation in leisure-time physical activity required financial resources. Since well-educated individuals earned more money than less-educated individuals, they were more capable of spending time on leisure-time physical activity.[43]

The relationship between employment status and physical activity was noteworthy. A previous study by Cheah and Poh[17] found that unemployed adults were less likely to be physically active when compared to those who were employed because they often lived a sedentary lifestyle. Cheah et al.[18] further concluded that because employed individuals had better health awareness than the unemployed, they tended to spend more time on physical activity. Similarly, Gaskin[29] found that employed adults had a higher tendency to meet physical activity guidelines when compared with their unemployed counterparts. These past findings were corroborated by the present study. Specifically, we found the likelihood of indulging in a highly active lifestyle to be higher among adults who were employed than the unemployed.

Consistent with our original hypothesis, adults who were aware of their BMI were more likely to be highly active and less likely to be inactive when compared with their counterparts without BMI awareness. This finding highlights the importance of physical activity in obesity prevention. The influence of BMI awareness on physical activity had not been

assessed in the past, but the association between BMI and physical activity was widely evidenced.[23,25,29] Past studies consistently found that obese and overweight individuals were less likely to devote their time to physical activity than those with normal weight. In another study, Reyes-Olavarria et al.[30] investigated the levels of physical inactivity in the Chilean population and found that being overweight was associated with reduced physical activity levels. However, because BMI data were unavailable to the researchers, the present study could not identify whether obesity and being overweight were risk factors for physical inactivity among Malaysian adults.

Although gender and marital status did not have independent effects on physical activity participation, they were risk factors for physical inactivity. The present study found that high-level physical activity was more frequent among males and married adults than females and unmarried adults. These outcomes corroborated the findings of Downward and Rasciute,[19] Werneck et al.[27] and Gay et al.[23] in that males were more likely to indulge in a physically active lifestyle than females. Cultural factors may be a plausible explanation for this finding. In most cultures, men tend to spend more time on physical activity, whereas women are likely to allocate more time to household activities.[17,27] Results from the present study were also consistent with the findings of Cheah et al.[18] and Choi and Kwon[31] in that married individuals spent more time on physical activity when compared with unmarried individuals. These results point to the influence of household commitments on physical activity as married individuals tend to place more efforts into improving their health by engaging in physical activity.[44]

The findings of the present study have important implications for policies directed toward improving physical activity levels in the Malaysian population. Policymakers are suggested to pay special attention to adults who have hypertension with a focus on older persons. An intervention aimed at promoting a physically active lifestyle while avoiding excessive exertion in this group of the population is worthy of consideration. For instance, if hypertensive adults reported having difficulties in performing physical activity, one could educate the adults about how to stay physically active by frequently engaging in less strenuous exercises. In addition, the findings of the present study emphasize the urgent need to promote a physically active lifestyle in the high-income and well-educated segments of the population. Information about how to integrate physical activity into a busy lifestyle could be highlighted. Language-based mass media, such as internet, radio, and television, could be used in nationwide health awareness campaigns to stress the disadvantages of being physically inactive. Moreover, since BMI awareness encourages participation in physical activity, an intervention measure aimed at promoting physically active lifestyle should be integrated with BMI awareness programmes.

Several limitations of the present study are noteworthy. First, the survey was conducted in 2016 and thereby could not reflect the recent scenario in Malaysia; however, the study was nationally representative and had a large sample size. Second, because of cross-sectional data, causalities could not be established. Third, the present study was unable to assess the types of physical activity engaged by respondents due to data limitations. Fourth, owing to resources constraints, different stages of hypertension and waist circumference were not measured in the survey. Fifth, information relating to BMI was unavailable to researchers. In spite of these limitations, the present study has numerous strengths: (1) this was an in-depth investigation of the moderating effect of age on the correlation between hypertension and physical activity; (2) we used ordinal regression to analyse factors associated with the likelihood of participating in low-, moderate- and high-level physical activity; and (3) the relationship between awareness of BMI and physical activity was explored. Future studies could extend the analysis of the present study by using longitudinal data, exploring other moderating variables, and including more explanatory variables, such as stages of hypertension, BMI and waist circumference. Examining the mediating effects of lifestyle variables on the relationships between sociodemographic factors and physical activity could also be a direction for future research.

Conclusion

Hypertension plays an important role in influencing levels of physical activity. The effects of hypertension on low- and high-level physical activity were moderated by age. Other factors that were associated with physical activity levels included gender, marital status, income, education, and employment status. More specifically, adults had a higher likelihood of being highly physically active if they were male, married, low-income earners, less educated, and employed. Furthermore, being aware of BMI increased the likelihood of living a highly active lifestyle.

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Conflict of interest

The authors have no conflict of interest to declare

Ethical approval

Ethical approval was sought from the Medical Research and Ethics Committee of Ministry of Health Malaysia (NMRR-16-524-30085). The approval date is 18 April 2016.

Consent

Written consent was obtained from respondents before the interviews.

Author contributions

YKC: Conceptualization, methodology, validation, formal analysis, investigation, writing – original draft, writing – review & editing. KKL: Methodology, validation, investigation, writing – review & editing, supervision. HI:

Methodology, validation, investigation, writing – review & editing. MFMY: Methodology, validation, investigation, writing – review & editing. CCK: Methodology, validation, investigation, writing – review & editing. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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